CSCOR NGOMEX: The Effects and Impacts of Hypoxia on Production Potential of Ecologically and Commercially Important Living Resources in the Northern Gulf of Mexico
NGOMEX – Spatially-explicit, High-resolution Mapping and Modeling to Quantify Hypoxia Effects on the Living Resources of the Northern Gulf of Mexico

PROJECT OBJECTIVES:

1. Conduct high resolution mapping of NGOMEX pelagic food web in relation of hypoxia.

2. Integrate our ecosystem measurements through a variety of models designed to assess the effects of hypoxia on pelagic food webs and production.

3. Quantify habitat suitability for economically important fishes.

4. Provide tools to forecast food-web interactions, habitat suitability and fish production in relation to hypoxia.
Baseline Field Sampling

- Zooplankton
- Temperature
- Dissolved oxygen
- Salinity
- Chlorophyll a

Fish Biomass
<table>
<thead>
<tr>
<th>Gear</th>
<th>EcosystemComponent</th>
<th>03</th>
<th>04</th>
<th>06</th>
<th>07</th>
<th>08</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTD</td>
<td>Temp,DO,Salinity,Chla,PAR</td>
<td>15</td>
<td>15</td>
<td>67</td>
<td>59</td>
<td>77</td>
<td>32</td>
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<tr>
<td>ADCP</td>
<td>Currents</td>
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<td>X</td>
<td>X</td>
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<td>FlowCytometry</td>
<td>Microbialfood web</td>
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<td>ZPPump</td>
<td>Mesozooplankton</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TAPS</td>
<td>Mesozooplankton</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Scanfish/CTD/OPC</td>
<td>Mesozooplankton,Temp,DO,Salinity,Chla</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Acoustics</td>
<td>PelagicFish</td>
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<tr>
<td>BottomTrawl</td>
<td>BenthicFish</td>
<td>67</td>
<td>40</td>
<td>31</td>
<td>X^1</td>
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<tr>
<td>MidwaterTrawl</td>
<td>PelagicFish</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X^1</td>
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<tr>
<td>DIDSON</td>
<td>Pelagic&amp;BenthicFish</td>
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</table>

Notes:
- X^1 indicates data not available.
Potential effects of hypoxia on coastal zooplankton

**Deleterious**

- **Direct**
  - Lethal
  - Sub-lethal, e.g.
    - Slowed development
    - Reduced reproductive success

- **Indirect**
  - Habitat reduction
  - Trophic interactions altered

**Beneficial**

- Refuge from less tolerant predators
- Habitat reduction could enhance prey encounter rates
- Selection for some species
Abundance ($\times 10^3$ individuals m$^{-3}$) vs. Dissolved oxygen (mg L$^{-1}$)

- The graph shows a clear transition from normoxic to hypoxic conditions.
- The normoxic-hypoxic transition is indicated by a vertical dotted line at approximately 2 mg L$^{-1}$ dissolved oxygen.

NGOMEX
NGOMEX: Relationship between zooplankton median depth and depth of the 2 mg ml$^{-1}$ oxycline.
## NGOMEX SURVEY COMPARISONS

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>2004</th>
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<tbody>
<tr>
<td>Area Mapped (km²)</td>
<td>28,697</td>
<td>28,746</td>
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<tr>
<td>Hypoxic Area (km²)</td>
<td>1,807</td>
<td>10,172</td>
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<tr>
<td>Mean Zooplankton (mg C m⁻³)</td>
<td></td>
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<tr>
<td>250-500µm ESD</td>
<td>0.77</td>
<td>0.98</td>
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<tr>
<td>500-1000µm ESD</td>
<td>1.34</td>
<td>1.39</td>
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<td>1000-1500µm ESD</td>
<td>1.01</td>
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<td>1500-2000µm ESD</td>
<td>0.71</td>
<td>0.54</td>
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<tr>
<td>2000-2500µm ESD</td>
<td>1.00</td>
<td>0.71</td>
</tr>
<tr>
<td>TOTAL</td>
<td>4.84</td>
<td>4.39</td>
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</table>
Taxonomic composition

23,500 ind m⁻³
1,600 ind m⁻³
15,700 ind m⁻³
3,600 ind m⁻³
Zooplankton-environment relationship

Axis 1: 11.1%

Axis 2: 3.6%

salinity

hypoxic area

vertical extent of hypoxia

river flow

temperature
Hypoxia and Pelagic Fish

- Alter spatial distribution
- Restrict vertical migrations
- Move to areas of poorer habitat quality (e.g. less food, change in temperature)
- Increased predator concentration
- Increased vulnerability to predation (e.g. increased light?)
Hypoxia and Pelagic Fish

- Increase prey concentration?
- Increase prey vulnerability (e.g. light)
- Better overall habitat conditions (e.g. growth)
- Can hypoxia be used as a refuge?
- Are there edge effects?
Transect F

Single layer Low Oxygen zone with little target activity ($S_v = -74$)

Targets throughout the layer with the exception of the very bottom ($S_v = -62$)
Gulf of Mexico—H Transect
Double Hypoxia Layer
Fish Density and Oxygen levels

2003 DD

2003 F
Growth Rate Potential

PREY DENSITY, LIGHT

WATER TEMPERATURE

FORAGING (f)

GROWTH (g)

GROWTH RATE POTENTIAL

Depth

Latitude

Oxygen availability
Figure 6 – Stomach contents from Atlantic bumper (top, n = 497) and striped anchovy (bottom, n=411).
Biomass Size Spectra as Indicators of Ecosystem Status

Unperturbed ecosystem

- theoretical slope = -1.0

Perturbed ecosystem

- steeper slope
Tropical Storm Edouard
Figure 9 – CTD profiles (left panels) and relative fish biomass (right panels) before (top panels) and after (bottom panels) a hurricane in August 2008.
Primary Production (g C m\(^{-2}\) y\(^{-1}\))

Fisheries Yield (kg ha\(^{-1}\) d\(^{-1}\))

- 15 Lakes > 10km\(^2\) (Oglesby 1977)
- 36 Marine Systems (Nixon 1988)

Chesapeake Bay
WE WILL USE MULTIPLE MODELS TO EVALUATE:

What is the effect of the spatial extent and seasonal timing of hypoxia on fish growth, recruitment and production potential?

How does hypoxia affect food web interactions in the pelagic zone? Specifically:

How will hypoxia affect the spatial distribution and predator-prey interactions of mobile organisms and zooplankton?

How does hypoxia affect habitat quality and suitability for economically and ecologically important fishes?

How will management decisions on nutrient loadings affect fisheries through its impact on the timing and extent of hypoxia?

What is the potential of strong wind events (and their relationship to climate change) to re-aerate the water column and alter the interactions of fish and their prey?

What are the most effective tools to forecast food-web interactions, habitat suitability, and fish production in relation to hypoxia?
NGOMEX PUBLICATIONS TO DATE:


Clouse, M., A. Adamack, S. Ludsin, D. Mason, S. Brandt, and H. Zhang. Feeding habits and trophic relationships of fish species in the northern Gulf of Mexico during summer hypoxic events. drafted.

